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The Effects of a Specific Resistance Program and a Weight Training Program Upon Strength Involved in and Speed of a Specific Motor Movement of the Discus Throw

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THE EFFECTS OF A SPECIFIC RESISTANCE PROGRAM AND A WEIGHT TRAINING PROGRAM UPON STRENGTH INVOLVED IN AND SPEED OF A SPECIFIC MOTOR MOVEMENT OF THE DISCUS THROW

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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THE EFFECTS OF A SPECIFIC RESISTANCE PROGRAM AND A WEIGHT TRAINING PROGRAM UPON STRENGTH INVOLVED IN AND SPEED OF A SPECIFIC MOTOR MOVEMENT OF THE DISCUS THROW

Abstract

DEAN E. DEKOK

Under the Supervision of Associate Professor Glenn E. Robinson

The purpose of this study was to determine the effects of a weight training program and a specific resistance training program upon strength involved in and speed of a specific motor movement of discus throwing.

Thirty freshmen male volunteer non-athletes enrolled in the basic instruction program of physical education at South Dakota State University during the spring semester of 1967 participated in the study. The subjects were selected by a table of random numbers from a total number of 91 volunteer freshmen male students. An arm strength test was administered, and the subjects were placed in rank order on the basis of the test. From the rank order data, three equated groups were derived with ten subjects in each group. Groups were designated by employing the track pillbox method. The three designated groups were experimental weight training group, experimental specific resistance group, and control group.

The subjects in the experimental groups participated in a six-week training program during which they met for eighteen training sessions. The weight training program consisted of a battery of eight exercises designed to improve overall strength development. A specific resistance exercise in the identical range-of-motion of discus throwing

was employed in the specific resistance training program which was designed to strengthen the muscles involved in throwing the discus.

The subjects in the experimental groups and the control group were tested at the beginning and at the end of the six-week training program. Angular horizontal abduction-flexion arm strength, combined leg extension and rotary hip strength, and speed of a specific motor movement of discus throwing were investigated. The data collected during the tests were recorded and analyzed to determine what effect the two training programs had upon the strength involved in and speed of a specific motor movement of discus throwing.

Results of the findings indicated that the specific resistance training program appeared more effective than the weight training program in developing strength; that neither the specific resistance training program nor the weight training program appeared to be an effective training aid in increasing the speed of a specific motor movement of discus throwing.

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Chapter I

INTRODUCTION

Justification of Study

The sport of track and field has become a prestige sport in respect to public interest during the past decade. This interest and appeal is primarily due to the consistent breaking of records in all events, and there appears to be no limit as to what track and field contestants can accomplish in the establishment of better times in races, farther distances in throwing and jumping events, and greater heights in the pole vault and high jump.

The modern track coach has become vitally interested in completed research and in the results which are concerned with the increasing of strength of the athlete and the relationship of increasing strength to performance. Weight training has become a popular off-season, pre-season, and even an in-season training program, and research indicates that weight training programs are beneficial. Hooks[1] has written:

> Weight training has completely revolutionized all track and field training methods. Where only a few years ago weight training was strictly taboo with track men, today it is extremely popular. The list of weight-trained track and field champions is endless.

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[1] Gene Hooks, Application of Weight Training to Athletics, p. 198.

Since such success has apparently accompanied weight training programs, it would seem that continued emphasis will be placed upon weight training programs. Recent research reveals that the application of progressive resistance exercises, using commercial devices, is also being employed as an effective means of increasing strength. Therefore, an attempt was made in this study to determine which of two selected training programs is most desirable for the increasing of strength with particular emphasis on strength involved and speed of the discus throwing action.

Statement of Problem

The purpose of this study was to determine the effects of a weight training program and a specific resistance program upon strength and speed of a specific motor movement of discus throwing.

Limitations of Study

1. This study was limited to freshmen volunteer male students at South Dakota State University who were enrolled in the basic service program of physical education.

2. This study was limited to subjects who were not members of any freshmen athletic team during or after the training program.

3. The study was conducted over a period of six weeks.

Definitions

1. Speed--the explosive ability to sling or thrust the discus through a 260 degree arc.

2. Strength--as defined by Reidman[2] is, "..the capacity of the whole body or any of its parts to exert force."

[2] Sarah R. Reidman, Physiology of Work and Play, p. 516.

3. Weight training--the lifting of weighted implements demanding muscular exertion with the hope that it will improve performance in an activity.

4. Resistance training--muscular exertion to overcome a resistance implied by some means other than a calibrated weighted implement and in which an improvement of performance is desired.

5. Isometric training--contraction of muscles pulling or pushing against an immovable object where muscle tension is developed but there is not any resulting movement of the object.

6. Isotonic training--contraction of muscles pulling or pushing against an object and movement of the object occurs.

7. "Exer-Genie"--a commercial resistance device used to create force that applied specific resistance to isolated muscle groups used in discus throwing.

8. Motor movement--a movement learned by repeatedly going through that exact movement.

9. Law of specificity--duplicating a specific movement in training program and working that movement, with the hope of developing the exact muscles involved in the specific movement.

10. Angular horizontal abduction-flexion--angular horizontal forward and away motion of the arm from the spinal cord and to a front horizontal position.

Chapter II

REVIEW OF RELATED LITERATURE

Introduction

Readings pertaining to weight training and specific resistance training programs are reported in this chapter. The cited literature describes the effects of related studies and findings along with opinions of chosen experts.

Report of Pertinent Findings

Murray and Karpovich[3] state that much experimentation with

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[3] Jim Murray and Peter V. Karpovich, Weight Training in Athletics, p. 130.

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weight training has been completed by top ranking competitors in track and field. Men like Bob Richards, Mal Whitfield, Otis Chandler, Parry O'Brien, Fortune Gordien, and Bob Backus have shown the merit of weight training for runners, jumpers, and throwers.

In one weight event, the shot put, it was learned by Otis Chandler[4] that seven of the first eleven shot putters to surpass 56

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[4] Murray and Karpovich, op. cit., p. 135.

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feet used weight training exercises. Of the remaining four persons, Chandler was unable to obtain data on two. Chandler was of the opinion also that the two who did not employ a weight training program would have been better shot putters if they had.

Hooks[5] emphasizes that the rising trend toward using weight

[5] Hooks, op. cit., p. 198

training for track and field training is considerable throughout the world. In Australia, England, and Russia the use of weights is reportedly a basic part of the training programs. Along with this trend there has been a somewhat paralleled course of a rash of broken track and field records.

DeVries[6] indicates that the development of strength increase

[6] Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics, p. 303.

in any one individual is the result of increasing the size of the individual muscle fibers in the muscles. It does not result from increasing the number of fibers. This increase in size is referred to as hypertrophy. Hypertrophy and strength are brought about only by subjecting a muscle to greater loads than to those which the muscle is normally accustomed. This is known as the overload principle.

Murray and Karpovich[7] further state that there is not any

[7] Murray and Karpovich, op. cit., p. 38.

unanimous agreement regarding the details of weight training. However, there is the agreement that in order to develop strength, the overload principle should be used. How heavy the overload should be is dependent upon the results desired. If strength is the desired end,

the weights should be hard to lift and there should be fewer repetitions while lighter weights and more repetitions should be used to develop endurance.

In relation to the weight events in track and field, Hooks[8]

[8] Hooks, op. cit., p. 199

emphasizes the need of weight training to develop necessary strength. Much greater strength is required in the arm and shoulder regions in the weight events than in the running and jumping events. In fact, exceptional strength is more important to the weight man than to almost any other athlete.

Steinhaus[9] revealed in 1952, when he interviewed Olympic

[9] Theodor Hettinger, Physiology of Strength, p. 6.

athletes in Helsinki, that most of these star athletes have a definite respect for the point of fatigue and do not train beyond it. This supports the well known fact that when training-whether for strength or skill-to push beyond the point of fatigue will result in a lower total effect than if training is interrupted before the fatigue point is reached.

Murray and Karpovich[10] state, along the same approach, that

[10] Murray and Karpovich, op. cit., pp. 50 and 72.

weight training for strength should be employed every other day. Also very important is the matter of rest periods between lifts to give the

muscles proper rest. After a rest of thirty to forty seconds, most lifters fail to lift heavier weights. An extended rest from five to eleven minutes also lowers the ability to lift. The best resting time seems to be from three to five minutes.

Hettinger and Muller[11] conducted a study on isometric

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[11] deVries, op. cit., p. 307

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training indicating that a maximum training effect could be obtained from one daily, six-second isometric contraction against two-thirds of an individual's maximum contraction strength. Greater force, duration, or number of repetitions did not increase the rate of strength gain, which was five percent per week when training was performed five times per week. Strength gains in various muscles improved from 33 to 181 percent.

Muller and Rohmert[12] in the same laboratory indicated serious

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[12] deVries, op. cit., p. 308.

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error, however, in the original work of Hettinger and Muller. It appears that strength gain approximately doubles when maximal isometric contraction is used as opposed to two-thirds of the maximum. Also, a higher end strength will result by increasing the number of six-second repetitions to between five and ten.

Logan[13] demonstrated in isotonic strength training that

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[13] deVries, op. cit., p. 306

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where greater resistance was applied greater strength gains also resulted. Of three experimental groups (15 persons in each), one group used weight resistance and one group used spring resistance to strengthen the knee extensors, while the third group was a control group. Using weight resistance the greatest resistance was encountered from 155 degrees to full extension, and in the spring resistance the greatest resistance was offered at 115 degrees. The weight training group when tested made significantly greater gains than the spring resistance at 155 degrees, and the spring resistance group showed significantly greater gains when tested at 115 degrees.

McCraw and Burnham[14] studied the effect of three training

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[14] Lynn W. McCraw and Stan Burnham, "Resistive Exercises in the Development of Muscular Strength and Endurance," Research Quarterly, March, 1966, pp. 79-88.

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methods upon the development of strength. The programs were: (1) isotonic method, whereby the subjects engaged in a regular progressive weight-training program, (2) isometric method, involving maximum muscular contractions for five to ten seconds, (3) speed method, whereby the muscles were contracted quite rapidly using light weights or resistance provided by the body itself. It was found that strength may be developed by any of the three methods but the isotonic and isometric methods developed strength the best.

Morehouse[15] states that one type of movement does not increase

[15] Laurence E. Morehouse, "Physiological Basis of Strength Development," (Exercise and Fitness, Illinois Colloquium), 1960, p. 195.

the strength or the performance of a different type of movement. To achieve the best training results, the pattern of movement must be duplicated. This is the principle or law of specificity, and it applies not only to the movement but also to the posture in which the movement is performed.

Hooks[16] further indicated that weight training for discus

[16] Hooks, op. cit., p. 206.

throwers should include special emphasis upon working the muscles utilized in throwing the discus. Extra work must be done with the motions that resemble the discus throw.

DeVries[17] considers isotonic methods of weight training to

[17] deVries, op. cit., p. 307.

have a distinct advantage over isometric in that strength gains are specific to the angle at which the resistance is encountered. Isotonic exercises can be designed to work the entire range of a motion in one contraction whereas several contractions at different angles would have to be worked throughout the entire range with isometric methods.

The Exer-Genie Company[18] indicates that they have developed

[18] Exer-Genie Incorporated, "Revolutionary Exerciser, Exer-Genie," pp. 1-6.

a breakthrough for combining both isometric and isotonic resistive exercises to a specific movement. The device used is the "Exer-Genie" which allows exact duplication of numerous movements. Each exercise is started by a ten-second isometric contraction and then followed through isotonically. It is claimed thereby to be able to develop strength in the entire range-of-motion by duplication of exact movements made against scientifically controlled isotonic and isometric resistance. The isometric contraction is primarily for great strength development while the isotonic contraction phase incorporates benefits of endurance and flexibility.

DeVries[19] responds to a highly argued point when he discusses

[19] deVries, op. cit., pp. 354-355.

the relationship of speed improvement to strength gains. He cites that considerable evidence indicates a strong relationship between gain in strength and gain in speed of a movement whether brought about by isotonic or isometric training. The gain in speed has also been demonstrated to result from both strength training that exercised the motion being tested and from training that merely improved the strength of the involved muscles but avoided training in the same movement.

Zorbas and Karpovich[20] conducted a study involving six

[20] Murray and Karpovich, op. cit., pp. 45-47.

hundred persons from eighteen to thirty years of age. The purpose was to determine whether or not weight lifters had slower rotary arm movement than non-weight lifters. Rotary movement was used because large muscles of the chest, arm, and back were used in a precisely performed movement. It was shown that the weight lifters were statistically significantly faster than the non-weight lifters.

Jordan and Nelson[21] studied the relationship between strength

[21] Bruce J. Jordan and Richard C. Nelson, "Relationship Between Strength and Speed in the Horizontal Adductive Arm Movement," AAHPER Convention, 1966, p. 18.

and speed in the horizontal adductive arm movement. It was concluded that a statistically significant correlation at the .01 level existed between strength and both angular and linear speed of the horizontal adductive arm movement.

Smith and Whitley[22] directed a study on the influence of

[22] Leon E. Smith and Jim D. Whitley, "Influence of Three Different Training Programs on Strength and Speed of a Limb Movement," Research Quarterly, March, 1966, pp. 132-142.

three different training programs on strength and speed of a limb movement. Considered was the horizontal flexion-adduction movement of the arm. The training programs lasted two days a week for ten weeks. Program (A) consisted of a six-second bout of static work at six

equidistant measurement angles in the horizontal flexion-adduction specific range. During the rest of the period, dynamic weight training exercises were done, avoiding the specific range. Program (B) moved a weighted box of 19.5 kg six times, as fast as possible, through the same test range movement. Program (C) swung the arm as fast as possible in the range of movement six times without any resistance. It was discovered that both program (A) and (B) made statistically significant gains in strength and speed at the .05 level. Program (A) had the largest gain in both speed and strength while the gain in program (C) was very slight.

Mickinney and others[23] investigated the effect of resistance through a throwing range-of-motion on the velocity of a baseball. A six-week training program was employed working out five days per week. Group I trained with an isotonic device called the "Exer-Genie" and was pulled through a normal overhand range-of-motion 30 times daily with the "Exer-Genie" set at 2.5 pounds resistance. Group II trained by throwing 30 times per day through the same range-of-motion without resistance. The findings indicated that the velocity gain of 8.106 m.p.h. in Group I was significant at the .01 level while Group II had a velocity gain of 2.947 m.p.h. which was not significant.

[23] Wayne C. McKinney, Bill Rowe, Jr., Jerry Lumpe, and Gene Logan, "The Effect of Resistance Through a Throwing Range-of-Motion on the Velocity of a Baseball," (Health Physical Education and Recreation Annual Conference), April 1 & 2, 1966.

Summary

There have been many experts who have stated that there is a definite need for weight training to build strength for track and field events. Likewise, many of the top ranking competitors do participate in some type of weight training program. Research also seems to indicate the success of strength building by using weight training.

Definite agreement is voiced that the way to build strength is through the overload principle. Dissension appears as to what means is the most successful in applying the overload principle, however. Isometric and isotonic methods both develop strength, but research presents varying evidence in clarifying which is superior. Usually isometric methods are recognized as developing great strength at one specific angle of a range-of-motion while isotonic methods develop strength throughout a whole range-of-motion and incorporate more flexibility and endurance.

A relatively new innovation is the application of the law of specificity to weight training. The benefits are that muscle strength may thereby be derived specific to the muscles used in a desired action. The "Exer-Genie" device is designed to attempt to efficiently exercise the law of specificity.

Gain in strength is generally supported by research to be accompanied by a gain in speed. Research indicates that a gain in speed results from either exercises specific to the motion being tested,

or from exercises that strengthen the muscles involved while avoiding the motion being tested.

Training for strength demands definite rest periods for the muscle to avoid the onset of fatigue. A strenuous strength program is suggested, to be conducted on an every other day basis. Also, a three to five minute rest is recommended between lifts of weights to give the muscle proper rest.

Chapter III

PROCEDURE FOR OBTAINING DATA

Introduction

Described in this chapter are the subjects, the instruments used for obtaining data, and the training programs.

Subjects

Subjects selected for this study were freshmen male volunteer non-athletes at South Dakota State University enrolled in the basic instruction program of physical education during the spring semester of 1967.

Thirty subjects were selected by a table of random numbers from a total number of ninty-one volunteer freshmen male students. An arm strength test was administered and the subjects were placed in rank order on the basis of the test. From the rank order data, three equated groups were derived with ten subjects in each group. Groups were designated by employing the track pillbox method. The three designated groups were: experimental group weight training (Group WT), experimental group specific resistance (Group SR), and Control Group (Group C).

The length of the study was for a duration of six weeks with training sessions being conducted three days a week on Monday, Wednesday, and Friday. The initial testing period was conducted on January 16, 1967, and the post-test period following the training

period was conducted on March 21, 1967. The control group was required to take only the initial and post-tests; the experimental groups underwent a prescribed program.

Instruments for Obtaining Information

Combined leg extension and rotary hip strength angular horizontal abduction-flexion arm strength, and speed of a specific motor movement of the discus throw were measured initially and finally to determine what effect the two training programs had upon the selected measures.

Angular Horizontal Abduction-Flexion Arm Strength Test

The cable tensiometer was employed to measure angular horizontal abduction-flexion arm strength. The measurement was taken with the arm horizontal and fully extended at a 180 degree angle with the shoulder. A specially designed belt (Figure 1) was used to immobilize the lower body parts in an attempt to aid in assuring isolation of angular horizontal abduction-flexion arms strength and to obtain objective results. The cable tensiometer was calibrated by the Engineering Department of South Dakota State University prior to the study.

The equipment used in the angular horizontal abduction-flexion arm strength test was the cable tensiometer, one "Exer-Genie", chain and snap, hand-grip apparatus, wall hook apparatus, foot placement markers, and the belt.

Figure 1. Angular Horizontal Abduction-Flexion Arm Strength Test

The instructions given to each subject by the tester are found in Appendix E.

Each subject was given three trials during the initial and post-tests. All three trials were recorded in tension pounds and immediately converted into pounds pulled. The average of the three trials was the score of each subject. The investigator administered an informal warm-up period prior to the test.

Combined Leg Extension and Rotary Hip Strength Test

The cable tensiometer was employed to measure the combined leg extension and rotary hip strength. The measurement was taken with the right knee forming a 130 degree angle with the upper and lower limbs of the leg. The arms were permitted to hang freely so as to not impair the strength movement of the extending and rotary action.

The equipment employed to measure the combined leg extension and rotary hip strength was the cable tensiometer, chain and snap, wall hook apparatus, goniometer, foot placement markers, and the belt.

The instructions given to each subject by the tester are found in Appendix F.

Each subject was given three trials during the initial and post-tests. All three trials were recorded in tensions pounds and immediately converted into pounds pulled. The average of the three trials was the score of each subject. The investigator administered an informal warm-up period prior to the test.

Specific Motor Movement Speed Test

The Hale Reaction-Performance Timer was used to measure the speed of a specific motor movement of discus throwing. The speed measurement was recorded as the time elapsed from the moment the discus left the contact pad until the arm propelled the discus to touch the termination pad to the nearest one-hundredth of a second (Figure 2). The subjects were placed on lines which were drawn to facsimilate the proper foot position of the discus throw. There also were lines on the floor extending an angle to allow for moving of the pads nearer or farther for individual differences in the subjects.

The equipment used in the specific motor movement speed test was the Hale Reaction-Performance Timer, contact pad, termination pad, a specially designed glove enclosing a discus, and the lines determining the angles on the floor.

The instructions given to each subject by the tester are found in Appendix G.

Training Program

The investigator employed two different training programs that extended throughout a six-week period and met three days per week. The selected battery of exercises for the weight training group (Group WT) was determined by the track coach at South Dakota State University and is presently employed in his training program. The specific resistance group (Group SR) employed a specific range-of-motion exercise. The specific range-of-motion was originated by the

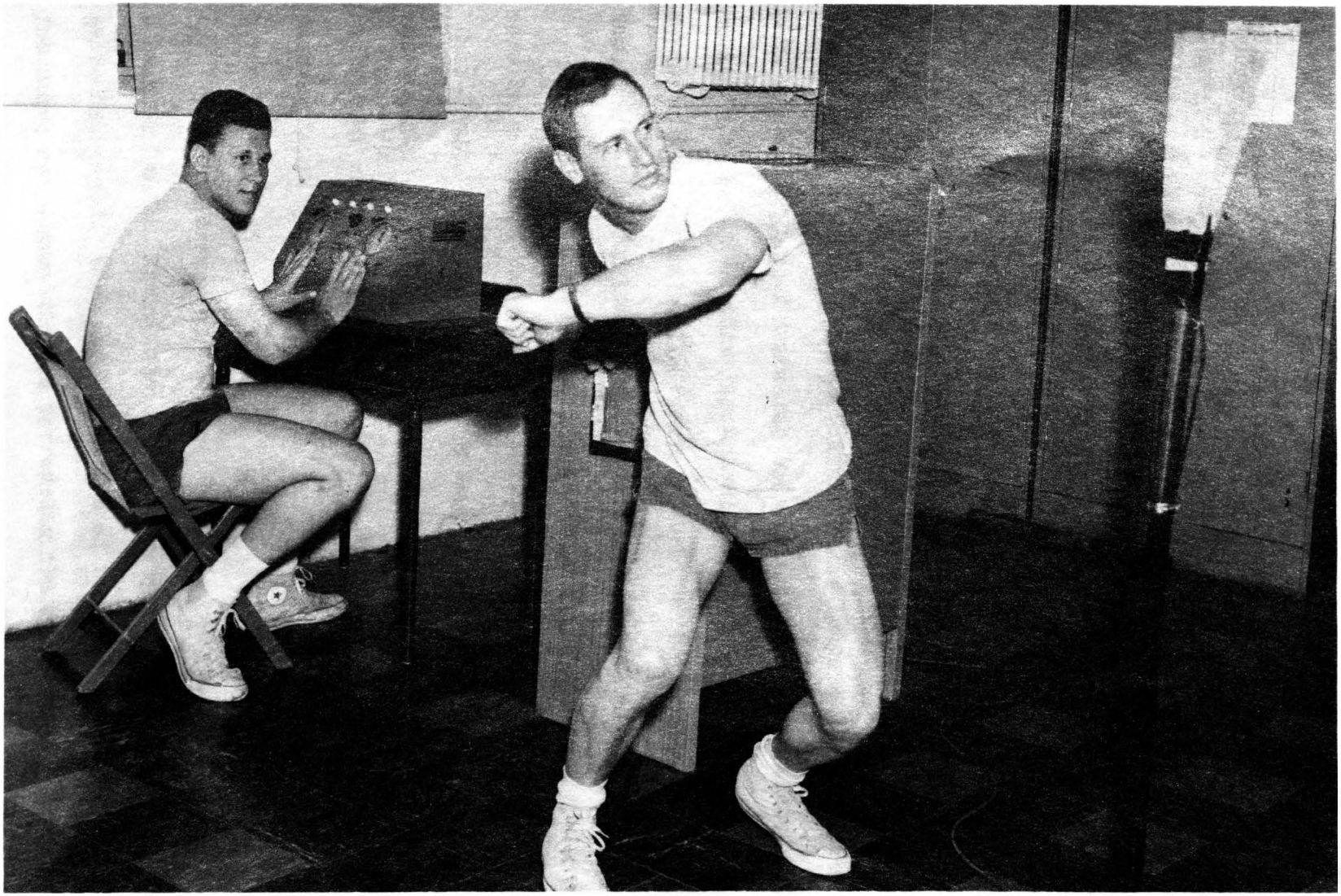

Figure 2. Specific Motor Movement Speed Test

investigator, and the ten-second isometric muscle contraction followed by an isotonic muscle contraction were recommended by the "Exer-Genie" Company.[24] Both of the training programs were designed as training

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[24] "Exer-Genie Incorporated," op. cit. ,p. 5.

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aids to discus throwers.

The specific resistance group (Group SR) participated in a heavy resistance training program. The resistance was applied by the means of two "Exer-Genie" devices, and the subjects experienced the specific motor movement of the discus throw (Figure 3). Employed were both the principles of isometric and isotonic muscle contraction using maximal muscle contraction throughout the exercise. The exercise was designed with the intention of strengthening the muscles involved in throwing the discus in the identical range-of-motion.

The subjects performing the specific resistance exercise were harnessed in the specially designed belt which was attached to an "Exer-Genie." The subject then grasped the hand-grip apparatus, which was attached to a second "Exer-Genie." Both "Exer-Genie" devices were secured on wall hooks. After placing the feet in the proper foot placement markers, the sequences as described in Appendix H were performed.

Resistance for the specific resistance exercises was held at a maximum level. Resistance was added progressively as the subject gained strength. Each day the amount of resistance was recorded to add incentive and competition in increasing the resistance. The resistance

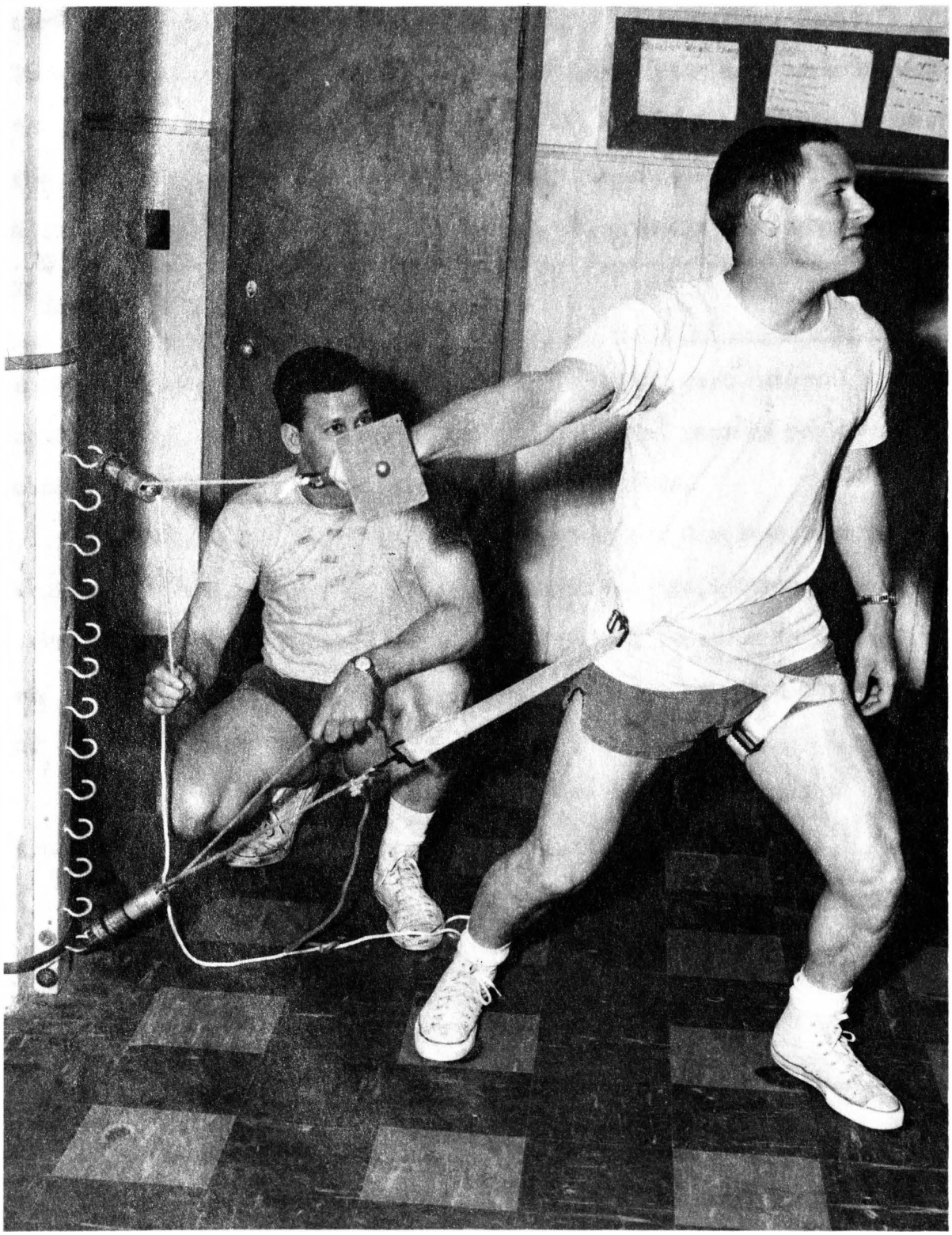

Figure 3. Specific Resistance Group Exercise

was recorded in "Exer-Genie" units calibrated on each "Exer-Genie." Five repetitions of the exercise were executed during each workout period and if the initial resistance was too great, the resistance was lessened for the final repetitions. Based upon the recommendation of Murray and Karpovich[25] that approximately a three to five minute rest interval be employed between lifts, an approximate four minute rest interval was employed in this investigation. Also, an informal warm-up period was conducted by the investigator prior to each session.

[25] Murray and Karpovich, op. cit., p. 50.

The weight training group (Group WT) was involved in a weight training program which was designed to improve overall strength development. The weight training exercises were isotonic in nature, and no exercises were employed involving the specific motor movement of the discus throw.

The following eight exercises were used in the weight training program:

1. Bench press
2. Inclined sit-ups with weights
3. Squats and heel raisers
4. Two arm curl
5. Tricep exercise
6. Leg press
7. Full military press
8. Dead lift

A detailed description of the eight exercises appears in Appendix I.

The weight training exercises were executed in three sets of ten repetitions with the tenth repetition being maximal. As soon as more than ten became relatively easy, additional weight was added. The subjects avoided working the same muscle groups by alternating the sets of repetitions, thus assuring proper muscle rest between sets of repetitions. An informal warm-up period was conducted by the investigator prior to each session.

Chapter IV

ANALYSIS OF DATA

Introduction

Presented in this chapter is the statistical analysis of the data collected on the pre-test and post-test of strength for the angular horizontal abduction-flexion of the discus throwing arm, strength for combined leg extension and rotary hip movement, and speed for a specific motor movement of discus throwing. The raw data appear in Appendixes A, B, and C.

Scoring of Data

The raw scores obtained on the speed of a specific motor movement of discus throwing were recorded in one-hundredths of a second and required no conversion. The raw scores obtained in the strength of the angular horizontal abduction-flexion of the discus throwing arm, and the strength of combined leg extension and rotary hip movement were converted immediately from tension pounds into pounds pulled. A conversion table prepared by the Engineering Department of South Dakota State University was used to make this conversion.

Reliability of Data

The reliability of all three test items was determined through the test-retest method. A rho or rank order correlation was

computed as explained by Garrett.[26] A reliability coefficient of

[26] Henry E. Garrett, Elementary Statistics, pp. 90-92.

+.843 was computed for the combined leg extension rotary hip movement strength test, a reliability coefficient of +.914 for the angular horizontal abduction-flexion strength test, and a reliability coefficient of +.943 for the test of speed of a specific motor movement of discus throwing.

Analysis of Data

The investigator employed the analysis of variance technique as suggested by Steel and Torrie.[27] The .05 level of significance was

[27] Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics, p. 101.

chosen to denote statistically significant differences between group means. An F-ratio equal to or beyond the .05 level of significance necessitated a rejection of the null hypothesis. Two and twenty-seven degrees of freedom were present in this investigation and an F-ratio equal to or greater than 3.35 at the five percent level was necessary to reject the null hypotheses. Duncan's New Multiple-Range Test as outlined by Steel and Torrie[28] was employed to compare the following

[28] Steel and Torrie, op. cit., p. 107.

pairs of means: specific resistance group to weight training group, specific resistance group to control group, and weight training group

to control group. The protection level was 90 percent for this study with three means being compared and with the alpha at .05. The LSR at 27 degrees of freedom for two means was 2.90. The LSR at 27 degrees of freedom and three means was 3.04.

Findings

Analysis of variance was applied to the three groups to determine the significance of differences between the effects of the treatments among the groups. The three tests investigated were: the strength of combined leg extension and rotary hip movement, strength of angular horizontal abduction-flexion arm movement, and speed of a specific motor movement of discus throwing. Tables I and II present a summary of the analysis of data among the groups. In order to reject the null hypotheses at the .05 level, an F-ratio equal to or greater than 3.35 was required.

Combined Leg Extension and Rotary Hip Strength

An F-ratio of .11 was obtained for the pre-test. This was not statistically significant at the .05 level. The null hypothesis was then accepted (Table I).

Angular Horizontal Abduction-Flexion Arm Strength Test

The obtained F-ratio of .0655 was not statistically significant at the .05 level for this pre-test. The null hypothesis was then accepted (Table I).

Table I

Summary of Analysis of Variance for Pre-tests Between Groups

Test	Source	df	SS	MS	F-ratio
Combined Leg Extension and	Between	2	139	69.5	.11
Rotary Hip Strength Test	Within	27	16435	608.7	
Angular Horizontal Abduction-	Between	2	3	1.5	.0655
Flexion Arm Strength Test	Within	27	619	22.9	
Specific Motor Movement	Between	2	.001	.0005	.313
Speed Test	Within	27	.042	.0016	

*Statistical significance at five percent level of significance.

Table II

Summary of Analysis of Variance for Post-Tests Between Groups

Test	Source	df	SS	MS	F-ratio
Combined Leg Extension and	Between	2	4035	2017.5	2.34
Rotary Hip Strength Test	Within	27	23,268	861.8	
Angular Horizontal Abduction-	Between	2	8	4	.246
Flexion Arm Strength Test	Within	27	439	16.259	
Specific Motor Movement	Between	2	.0082	.0041	2.41
Speed Test	Within	27	.0447	.0017	

*Statistical significance at five percent level of significance.

Specific Motor Movement Speed Test

An F-ratio of .313 was obtained for this pre-test. This was not statistically significant at the .05 level. The null hypothesis was then accepted (Table I).

Combined Leg Extension and Rotary Hip Strength Test

The obtained F-ratio of 2.34 was not statistically significant at the .05 level in the post-test. Therefore, the null hypothesis was accepted (Table II).

Angular Horizontal Abduction-Flexion Arm Strength Test

The obtained F-ratio of .246 was not statistically significant at the .05 level in the post-test. Therefore, the null hypothesis was accepted (Table II).

Specific Motor Movement Speed Test

The obtained F-ratio of 2.41 was not statistically significant at the .05 level in the post-test. Therefore, the null hypothesis was accepted (Table II).

Duncan's New Multiple Range Test was applied to the three groups to determine the significance of differences between the effects of the treatments within the groups. The three tests investigated were: the strength of combined leg extension and rotary hip movement, strength of angular horizontal abduction-flexion arm movement, and speed of a specific motor movement of discus throwing. Tables III and IV present the summary of the statistical data concerning Duncan's New Multiple-Range Test. The protection level was 90 percent for this study

Table III

Summary of Duncan's New Multiple-Range Test for Weight Training Group, Specific Resistance Group, and Control Group

	Pre-Test of Combined Leg Extension and Rotary Hip Strength (Pounds)		
Rank	1	2	3
Mean	160.0	161.7	165.2
Group	(Group SR)	(Group WT)	(Group C)

	Post-Test of Combined Leg Extension and Rotary Hip Strength (Pounds)		
Rank	1	2	3
Mean	167.3	181.0	195.7
Group	(Group C)	(Group WT)	(Group SR)

	Pre-Test of Angular Horizontal Abduction Flexion Arm Strength (Pounds)		
Rank	1	2	3
Mean	27.7	28.0	28.5
Group	(Group C)	(Group SR)	(Group WT)

Any two means not underscored by the same line are significantly different.
Any two means underscored by the same line are not significantly different.
Protection level was at 90 degrees at .05 level (Alpha error .05 when 3 groups compared).

Table IV

Summary of Duncan's New Multiple-Range Test for Weight Training Group, Specific Resistance Group, and Control Group

	Post-Test of Angular Horizontal Abduction-Flexion Arm Strength (Pounds)		
Rank	1	2	3
Mean	27.5	27.7	28.7
Group	(Group C)	(Group WT)	(Group SR)
	Pre-Test of Speed of a Specific Motor Movement (Seconds)		
Rank	1	2	3
Mean	.363	.373	.376
Group	(Group C)	(Group WT)	(Group SR)
	Post-Test of Speed of a Specific Motor Movement (Seconds)		
Rank	1	2	3
Mean	.366	.395	.405
Group	(Group C)	(Group WT)	(Group SR)

Any two means not underscored by the same line are significantly different.
Any two means underscored by the same line are not significantly different.
Protection level was at 90 degrees at .05 level (Alpha error .05 when 3 groups compared).

with three means being compared and with the alpha at .05 level. The LSR at 27 degrees of freedom for two means was 2.90. The LSR at 27 degrees of freedom and three means was 3.04.

Pre-Test of Combined Leg Extension and Rotary Hip Strength

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the specific resistance group to the weight training group, the specific resistance group to the control group, and the weight training group to the control group. In this investigation no significant statistical difference was found (Table III).

Post-Test of Combined Leg Extension and Rotary Hip Strength

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the weight training group, the control group to the specific resistance group, and the weight training group to the specific resistance group. A mean difference of 28.4 was found between the control group and the specific resistance group which was statistically significant (Table III).

Pre-Test of Angular Horizontal Abduction-Flexion Arm Strength

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the specific resistance group, the control group to the weight training group, and the specific resistance group to the weight training group. In this investigation no significant statistical difference was found (Table III).

Post-Test of Angular Horizontal Abduction-Flexion Arm Strength

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the weight training group, the control group to the specific resistance group, and the weight training group to the specific resistance group. In this investigation no significant statistical difference was found (Table IV).

Pre-Test of Speed of a Specific Motor Movement

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the weight training group, the control group to the specific resistance group, and the weight training group to the specific resistance group. In this investigation no significant statistical difference was found (Table IV).

Post-Test of Speed of a Specific Motor Movement

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the weight training group, the control group to the specific resistance group, and the weight training group to the specific resistance group. In this investigation no significant statistical difference was found (Table IV).

Summary of Findings

Statistically significant improvement was noted at the .05 protection level for the specific resistance group in strength gain when compared to the control group in strength of combined leg extension and rotary hip movement on the post-test when analyzed by Duncan's New Multiple-Range Test.

Statistical significant difference was not noted in any other treatments of the investigation.

Discussion of Findings

The statistically significant improvement noted for the specific resistance group when compared to the control group in strength of combined leg extension and rotary hip movement could have been an expected result. Similar results have been reported to develop under similar training programs.

The loss of speed of a specific motor movement of discus throwing from the pre-test to the post-test for both the weight training group and specific resistance group was not significant. The writer felt that this loss of arm speed may have been a result of employing a very strenuous training program, and fatigue may possibly have influenced the post-test.

Chapter V

SUMMARY

Problem

The purpose of this study was to determine the effects of a weight training program and a specific resistance program upon strength and speed of a specific motor movement of discus throwing.

Data

Subjects who participated in this investigation were freshmen male students in the physical education basic instruction program at South Dakota State University during the spring semester of 1967. The subjects were non-athletes and were selected randomly from 91 volunteers. A six-week training program, 18 sessions in length, was administered to the two experimental groups, each composed of ten subjects. An additional ten subjects constituted the control group. The workloads for both experimental groups were held at a maximum level throughout the six-week program.

A pre-test and post-test were administered at the beginning of and following the training program. The tests employed were: strength of combined leg extension and rotary hip movement, strength of angular horizontal abduction-flexion of the throwing arm, and speed of a specific motor movement of discus throwing.

Data obtained during testing were collected and analyzed by employing the analysis of variance and Duncan's New Multiple-Range Test.

Findings

1. No statistically significant difference was found between the two experimental and the control groups after any of the three pre-tests: combined leg extension and rotary hip strength, angular horizontal abduction-flexion arm strength, and speed of a specific motor movement.

2. The specific resistance group when compared to the control group in combined leg extension and rotary hip strength after the post-test, had a statistically significant gain in strength.

3. No statistically significant difference was found between the two experimental groups and the control group after the post-test on strength of angular horizontal abduction-flexion of the throwing arm.

4. No statistically significant difference was found between the two experimental groups and the control group after the post-test on speed of a specific motor movement of the discus throw.

Conclusions

From the findings of this investigation the following conclusions were drawn: the specific resistance program appeared more effective than the weight training program in developing strength; neither the specific resistance program nor the weight training program appeared to be an effective training aid in increasing the speed of a specific motor movement of the discus throw.

Afterthoughts on Recovery of Speed after the Post-Test

To satisfy the investigator's curiosity concerning the effects of rest following the strenuous training program, a final post-test on speed of a specific motor movement of discus throwing was administered to five available subjects of the specific resistance group. The test was administered April 12, 1967. (The raw data appears in Appendix D).

The *t*-test as explained by Garrett[29] was applied to the data collected in the pre-test and the final post-test on the speed of a specific motor movement of the five specific resistance subjects. The .05 level of significance was chosen to denote statistically significant differences for the *t*-ratio. A *t*-ratio at or beyond the .05 level necessitated a rejection of the null hypothesis and four degrees of freedom were present in this part of the investigation.

[29] Garrett, *op. cit.*, pp. 129-132.

Although there was no significant statistical improvement from the pre-test to the final post-test, there was an increase of speed. The writer felt that the lay-off from the strenuous training program possibly indicated a rest was necessary to overcome fatigue developed from the training program. Had a series of tests been administered after the post-test, perhaps a definite positive speed trend analysis curve would have resulted for both training programs.

Recommendations for Further Study

Based on the information obtained from this study, the following recommendations were made by the investigator:

1. That a similar study be conducted using a longer training program.

2. That a similar study be conducted using experienced discus throwers.

3. That a similar study be conducted incorporating flexibility and explosive action exercises into the training program.

4. That a similar study be conducted with comparison of variable workloads employed to weight training and specific resistance training.

5. That a similar study be conducted with a series of tests after the post-test to indicate a trend analysis curve of strength and speed gain or loss after the training program is concluded.

6. That a similar study be conducted using both weight training and specific resistance training by the same group.

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APPENDIXES

Appendix A

RAW DATA: CONTROL GROUP

Pre-Test

Subject Number	Leg-Hip Strength (Pounds)	Arm Strength (Pounds)	Motor Movement Speed (Seconds)
1	215	25	.32
2	167	31	.37
3	195	30	.34
4	152	28	.34
5	152	25	.43
6	144	28	.33
7	166	23	.39
8	164	30	.36
9	140	29	.38
10	157	28	.37
	$\bar{X}$=165.2	$\bar{X}$=27.7	$\bar{X}$=.363

Post-Test

1	211	26	.33
2	174	33	.36
3	203	29	.37
4	161	26	.36
5	142	25	.39
6	150	26	.32
7	165	26	.42
8	161	30	.39
9	145	27	.36
10	161	27	.36
	$\bar{X}$=167.3	$\bar{X}$=27.5	$\bar{X}$=.366

Appendix B

RAW DATA: WEIGHT TRAINING GROUP

Pre-Test

Subject Number	Leg-Hip Strength (Pounds)	Arm Strength (Pounds)	Motor Movement Speed (Seconds)
1	166	23	.44
2	136	23	.41
3	164	41	.35
4	144	24	.37
5	138	25	.36
6	189	29	.38
7	167	34	.34
8	140	28	.38
9	146	26	.37
10	227	32	.33
	$\bar{x}$=161.7	$\bar{x}$=28.5	$\bar{x}$=.373

Post-Test

1	170	23	.48
2	157	24	.43
3	184	39	.38
4	166	24	.39
5	151	25	.39
6	218	30	.41
7	204	32	.37
8	160	28	.39
9	168	25	.37
10	232	27	.34
	$\bar{x}$=181.0	$\bar{x}$=27.7	$\bar{x}$=.395

Appendix C

RAW DATA: SPECIFIC RESISTANCE GROUP

Pre-Test

Subject Number	Leg-Hip Strength (Pounds)	Arm Strength (Pounds)	Motor Movement Speed (Seconds)
1	153	25	.41
2	132	30	.39
3	170	27	.29
4	176	40	.40
5	151	32	.37
6	157	26	.32
7	159	24	.36
8	201	29	.35
9	174	27	.47
10	127	20	.40
	$\bar{x}$=160.0	$\bar{x}$=28.0	$\bar{x}$=.376

Post-Test

1	202	26	.46
2	163	26	.44
3	199	29	.35
4	243	35	.36
5	194	32	.39
6	161	30	.34
7	195	25	.39
8	207	29	.38
9	255	34	.49
10	138	21	.45
	$\bar{x}$=195.7	$\bar{x}$=28.7	$\bar{x}$=.405

Appendix D

RAW DATA: SPEED OF SPECIFIC RESISTANCE GROUP

Subject Number	Pre-Test (Seconds)	Post-Test (Seconds)	Final Post-Test (Seconds)
1	.29	.35	.32
2	.32	.34	.30
3	.37	.39	.35
4	.35	.38	.34
5	.47	.49	.42
	$\bar{x}$=.360	$\bar{x}$=.390	$\bar{x}$=.346

Appendix E

The following are the instructions given to the subject by the tester for the angular horizontal abduction-flexion arm strength test:

1. Place the right foot in the proper foot placement marker and manipulate the left foot so that your stance feels comfortable, but have the left foot pointing in the direction indicated by the left foot placement marker.

2. Extend the right leg and right hip forward and force the belt held isometrically by the "Exer-Genie".

3. Arch the back, turn the head slightly to the left, keep the right arm fully extended and horizontal at a 180 degree angle with the shoulder.

4. Force into the angular horizontal abduction-flexion movement as hard as possible without jerking.

Appendix F

The following are the instructions given to the subject by the tester for the combined leg extension and rotary hip strength test:

1. Place the right foot in the proper foot placement marker and manipulate the left foot so your stance feels comfortable, but have the left foot pointing in the direction indicated by the left foot placement marker.

2. Keep the angle formed at the right knee at a 130 degree angle as indicated by the goniometer.

3. Keep the back arched and chest upright, the head slightly to the left, allow the arms to hang freely and aid in rotary movement.

4. Force into the combined leg extension and rotary hip movement as hard as possible without jerking.

Appendix G

The following are the instructions given to the subject by the tester for the specific motor movement speed test:

1. Adjust the height of the contact pad so that the middle of the pad is parallel to the top of the crest of your illium; adjust the height of the termination pad so that the middle of the pad is parallel to your arm extended out horizontally.

2. Adjust the distance of the pads from the center of the 260 degree angle according to your arm length.

3. Place the right foot so it extends along the 235 degree angle formed with the contact pad; place the left foot to allow for a comfortable stance in the same predetermined direction used in the strength tests.

4. Crouch to a ready position, contact the discus to the contact pad, turn your head slightly to the left and position the left arm so as to be able to lead the upper part of the body with the left elbow.

5. Using leg extension and hip rotation, upper body rotation, and angular horizontal abduction-flexion of the throwing arm, propel the discus through the arc formed by the two pads as fast as possible when the horn sounds; follow through after the movement is performed.

Appendix H

The following sequences are the sequences of the specific resistance group training exercise:

1. Isometric extension of the legs and rotary hip movement for ten seconds from a deep crouch position.

2. Isotonic contraction to half completion of the movement.

3. Isometric leg extension and rotary hip movement for a ten-second period.

4. Isotonic contraction to full leg extension and hip rotation.

5. Exertion of the lower body is stopped at this position and held stationary at this point for the remainder of the exercise.

6. Isometric angular horizontal abduction-flexion of the right arm for ten seconds with the arm trailing the body.

7. Isotonic contraction to approximately a 180 degree angle formed by the shoulder and arm horizontally extended.

8. Isometric angular horizontal abduction-flexion of the right arm for ten seconds.

9. Isotonic contraction through the completion of the movement.

Appendix I

The following eight exercises were used in the weight training program:

1. Bench press-- The subject reclined upon his back on a bench with the weighted barbell at his chest. The barbell was pushed to arm's length and then lowered to the chest.

2. Inclined sit-ups with weights-- The subject reclined upon his back on the inclined bench with his feet secured on the top end of the bench. Weights were grasped in his hands behind his head. The subject raised himself to a sitting position and then lowered his back to the bench.

3. Squats and heel raisers-- The subject used the upright power racks which held the weighted barbell at about a quarter squat height when resting on the shoulders behind the neck. The subject straightened up, raised his heels at the end of the full leg extension and then returned to the quarter squat position.

4. Two arm curl-- The subject held the weighted barbell against the front of the thighs with palms out. The elbows were kept close to the sides and the weight was brought up to the chest and then lowered to starting position.

5. Tricep exercise-- The subject placed his feet upon a chair and his hands were placed behind him upon another chair to form a pike position of the body. Weights were then placed upon the subject's lap. He then lowered himself into a deep dip position and then returned to the original position.

Appendix I (Continued)

6. Leg press-- The subject rested his shoulders upon a vertical padded rest to immobilize the body. He then planted his feet upon the foot rests of the horizontal power racks that were attached to sliding weights. The foot rests were pushed outward in a leg extension and plantar flexion movement and returned again.

7. Full military press-- The subject sat upon a stool with the weighted barbell grasped in front of the chest close to the body at shoulder height. The subject raised the barbell to an extended arm position above the head and returned it to the original position.

8. Dead lift-- The subject bent over the weighted barbell resting on the floor and grasped the barbell in an alternate grip. The subject rose to an erect position using the muscles of the legs and upper back and then returned the barbell to the original position.